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Research

Performance of Promising Potato Clones for Growth and Yield Characters in Bhaktapur, Nepal

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Abstract*: A study was conducted during 2018 in Bhaktapur district of Nepal (1348 masl) to evaluate the growth and yield of promising potato clones. Five promising clones of potato (PRP 35861.18, CIP 384866.5, PRP 226267.11, CIP 388676.1 and PRP 85861.11) provided by National Potato Research Programme, Nepal and 'Desiree' (released variety as a check) were arranged in a Randomized Complete Block Design with 4 replications. The results revealed that there was significant variation regarding the growth parameters of the clones. Desiree showed the earlier and the highest germination as compared to the promising clones. The highest plant vigor and plant height was observed in PRP 35861.18 while the highest stem thickness and ground cover were in PRP 226267.11. All the 5 promising potato clones were resistant against the late blight while the check variety (Desiree) was highly susceptible. Higher yield was obtained in PRP 85861.11 (24.5 mt/ha), CIP 388676.1 (24.43 mt/ha) and PRP 226267.11 (24.38 mt/ha). The tuber distribution also showed significant variation with the highest oversize tuber number per plant as observed with CIP 388676.1. The farmer's ranking and organoleptic taste of boiled potato was higher for PRP 226267.11 and PRP 85861.11 respectively. Further research in other agro-ecological zones should be carried out before releasing these clones as new variety.*

Keywords *: Late Blight, Organoleptic, Potato, Yield*

INTRODUCTION

Potato, popularly known as king of vegetables, is one of the most important crops of Nepal. It is grown in all agro- ecological zones of 77 districts ranging from 100 to 4400 masl

(Dhital & Khatri, 2004). People residing in terai and mid hills consume potato as a major vegetable while in high hills it is used as a staple food. It is the fourth most important crop after rice, wheat and maize; however holds first position in productivity. Its annual production is 2,805,582 tons with the productivity of 14.03 mt/ha (MoAD, 2017). It is highly nutritious food constituting good source of energy, vitamins and minerals. Potato cultivation is a major source of income for small holder farmers in mid and high hills. It plays vital role in maintaining the food security and eliminating the poverty and malnutrition in Nepal. Despite its huge importance and cultivation potentiality, its production is very low as compare to the neighboring countries. Many factors are responsible for low yield of potato but lack of high yielding and late blight resistant varieties is the bottleneck constraint for potato cultivation in Nepal.

The production of existing cultivated varieties is not enough to meet increasing market demand. Farmers are forced to recycle the same low yielding variety for years. Variety development is a continuous process to replace old degenerating varieties with new improved varieties. National Potato Research Programme (NPRP) is responsible to conduct series of on-station and on-farm trials for developing new variety. On-farm trials are important to speed up the variety development process and enhance the adoption of new varieties in farm communities (Romney et al., 2003; Assefa et al., 2005). Besides, it enables the incorporation of farmers' opinions and ensures testing of varieties under farmers' management. Therefore as a part of on-farm trials, the experiment was conducted to evaluate growth and yield performance of promising potato clones in Bhaktapur and hence improve the productivity of potato through selection of appropriate potato clones in Bhaktapur. These clones were tested in various trials of several stations of the country but in Bhaktapur they were introduced for the first time in the present study.

MATERIALS AND METHODS

Five promising potato clones PRP 35861.18, CIP 384866.5, PRP 226267.11, CIP388676.1, and PRP 85861.11 were brought from NPRP, Khumaltar, Lalitpur and planted in farmers' field along with Desiree as check variety in winter-spring season of 2018. The experiment was laid out in Randomized Complete Block Design with 4 replications in Bhaktapur (1348 masl). The ridge of 3m long was prepared using potato ridge maker at a spacing of 60 cm. Well sprouted potato tuber seed of 25-30 g containing at least 2 eyes were planted at 25cm apart. The individual plot size was 7.2 m^2 with four ridges containing 12 plants each. The plot was fertilized at the rate of 100:100:60kg N:P_2O5:K_2O and 20mt FYM per hactare. The cultural practices and observation techniques were performed as per the recommendation of NPRP (Khatri et al., 1999). Observations were recorded on growth and

yield characters. Plant Uniformity was recorded using 1to 5 scale [1 = Very poor (completely heterogeneous in plant size and vigour), 2 = Poor (Some heterogeneous in plant size and plant vigour), 3 = Fair (average or acceptable), 4 = Good (relatively high homogeneity in plant size, plant vigour and growth) and 5 = Excellent (completely homogeneous in plant size, plant vigour and growth) (Khatri et al., 1999)]. Plant vigour was also recorded using 1 to 5 scale [1 = very weak (all the plants are small, <20 cm), few leaves, weak plants, very thin stems and light green color, 2 = 75% the plants are small (<20 cm) or all the plants are between 20 and 30 cm, the plants have few leaves, thin stem and light green color, 3 = medium, intermediate or normal, 4 = vigorous, 75% of the plants are over 50 cm, robust with foliage of dark green color, thick stems and leaves very well developed, and 5 = very vigorous, all the plants are over 70 cm and ground coverage is complete. The plant are robust, with thick stems and abundant foliage of dark green color. (Khatri et al., 1999)].

Data entry, management and descriptive analysis was done using MS Excel 2007. ANOVA and DMRT were done using R 3.5.1 and R-Studio 1.1.453.0 version (R core team, 2017) and significance level was defined at 5%.

RESULTS

Growth characters

The results of germination, plant uniformity and vigour are presented in Table 1. Significant variation in germination among the clones was observed at 30 DAP. Desiree showed the higher germination as compared to the promising potato clones of CIP. PRP clones showed similar germination to 'Desiree' indicating competitiveness of new clones to an established early variety. The germination of clones was found statistically non significant at 45 DAP. PRP 85861.11 and PRP 35861.18 were similar but superior to Desiree for plant uniformity at 60 DAE while the variation was non significant at 30 DAE. PRP 35861.18 had higher plant vigor at both 45 DAE and 60 DAE than CIP 388676.1.

Table 1. Germination, uniformity and plant vigor of potato clones in Bhaktapur, 2018

Treatment	Germination (%)		Uniformity		Plant Vigor	
	30DAP	45DAP	45 DAE	60DAE	45DAE	60DAE
PRP 35861.18	63.46±12.49^{a}	98.75±2.5	4.5±0.58	4.5±0.58^{ab}	3.75±0.96^{a}	4.25±0.5^{a}
CIP 384866.5	30.21±19.65^{b}	92.71±7.12	3.25±0.5	3.5±0.58^{c}	2.75±0.5^{bc}	3.75±0.5^{ab}
PRP 226267.11	54.17±36.49^{ab}	93.75±7.98	4.00±0.82	4±0.82^{abc}	3.25±0.5^{ab}	4.25±0.5^{a}
CIP 388676.1	34.38±27.72^{b}	90.63±7.12	3.75±0.96	3.75±0.96^{bc}	2.25±0.5^{c}	3.0±0.00^{c}

PRP 85861.11	55.13±18.12^{ab}	92.29±3.56	4.25±0.96	5±0.0^{a}	3.25±0.5^{ab}	3.50±0.58^{bc}
Desiree	73.75±17.46^{a}	97.92±4.17	3.5±0.56	3.25±0.5^{c}	3±0.0^{abc}	3.00±0.00^{c}
F test	**	NS	NS	*	*	**
P value	0.00002	0.10719	0.25	0.00179	0.0175	0.00163
CV%	30.26	4.65	19.76	16.46	16.89	11.9
LSD	23.65	6.614	1.15	0.99	0.77	0.65

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Note: DAP=Days after Planting, DAE= Days after emergence, LSD=Least Significant Difference, CV%=Coefficient of Variation Percentage

The results of stem thickness, plant height and ground cover of the potato clones are presented in Table 2. The highest stem thickness was shown with PRP 226267.11. Plant height also varied significantly among the clones. At 45 DAE PRP 35861.18 was the tallest while at 60 DAE PRP 35861.18 and PRP 226267.11 were the tallest among the tested clones. Desiree was the most dwarf clone in both observations. Statistically significant variation was observed in ground cover of clones. PRP 226267.11 and PRP 85861.11 were recorded as superior to Desiree for ground cover.

Table 2. Effect of clones on stem thickness, plant height and ground cover in Bhaktapur, 2018

Treatment	Stem thickness(cm)		Plant height (cm)		Ground cover at 60 DAE
	45 DAE	60 DAE	45DAE	60DAE	
PRP 35861.18	3.01±0.22^{b}	3.16±0.06^{bc}	50.95±6.47^{a}	62.45±4.1^{a}	75±8.16^{ab}
CIP 384866.5	3.36±0.53^{ab}	3.31±0.2^{ab}	37.80±6.62^{c}	51.16±6.11^{b}	75±4.08^{ab}
PRP 226267.11	3.69±0.53^{a}	3.54±0.35^{a}	44.70±6.76^{b}	61.50±11.6^{a}	80±4.08^{a}
CIP 388676.1	3.12±0.07^{b}	2.9±0.26^{c}	30.75±3.87^{d}	39.70±5.24^{c}	48.75±4.79^{c}
PRP 85861.11	3.27±0.46^{b}	3.08±0.22^{bc}	42.90±6.10^{b}	49.20±3.67^{b}	77.50±6.45^{a}
Desiree	3.24±0.26^{b}	3.0±0.23^{bc}	33.63±5.46^{d}	40.88±4.52^{c}	67.5±6.45^{b}
P value	0.0281	0.00762	2.84e-07	1.47e-06	3.95e-05
F- test	*	**	***	***	***
LSD	0.38	0.32	4.15	6.10	9.39

CV%	7.65	6.67	6.86	7.97	8.82

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Note: DAE= Days after emergence, LSD=Least Significant Difference, CV%=Coefficient of Variation Percentage

Among the 6 tested clones, the growth pattern of PRP 35861.18 was found as lodging, CIP 388676.1 as erect and the remaining 4 clones as spreading type. CIP 388676.1 was categorized as late maturity type (>135), Desiree as early type (<115) and remaining 4 clones as medium maturity type (115-135). All 5 promising potato clones were seen resistant against late blight while Desiree was highly susceptible.

Table 3. Variation in growth characters among potato clones in Bhaktapur, 2018

Treatment	**Growth Habit**	**Maturity**	**Late Blight**
PRP 35861.18	Lodging	Medium	Mild Resistant
CIP 384866.5	Spreading	Medium	Resistant
PRP 226267.11	Spreading	Medium	Resistant
CIP 388676.1	Erect	Late	Highly Resistant
PRP 85861.11	Spreading	Medium	Highly Resistant
Desiree	Spreading	Early	Highly Susceptible

Yield characters

The tuber distribution by weight and number as well as yield of the tested clones is illustrated in Table 4. Significantly higher USN and USW per plant was reported with PRP 85861.11 among the tested clones. SSN and SSW per plant also varied significantly among the clones. PRP 85861.11 produced the highest SSN while PRP 85861.11 and PRP 35861.18 gave the highest SSW per plant. Similarly the significant highest OSN and OSW per plant was observed with CIP 388676.1

Table 4. Effect of clones on yield parameters of potato in Bhaktapur, 2018

Treatments	USN / plant	USW / plant	SSN / plant	SSW / Plant	OSN/ Plant	OSW / plant	Yield (mt/ha)
PRP 35861.18	3.9 ±1.16^{b}	53.85 ±13.37^{b}	4.95 ±0.74^{ab}	173.25 ±28.94^{a}	1.35 ±0.41^{b}	88.65 ±29.44^{b}	21.05 ±3.20^{ab}
CIP 384866.5	6.75 ±2.75^{b}	84.25 ±36.60^{ab}	4.25 ±1.05^{bc}	137.25 ±36.34^{ab}	0.90 ±0.68^{b}	65 ±53.26^{b}	19.1 ±3.35^{b}

PRP 226267.11	5.95 ±2.09^{b}	72.00 ±17.76^{b}	4.95 ±1.41^{ab}	168 ±36.34^{a}	1.60 ±0.82^{b}	125.75 ±89.33^{b}	24.38 ±5.49^{a}
CIP 388676.1	5.1 ±3.93^{b}	69.1 ±52.51^{b}	3.05 ±1.15^{c}	101.1 ±33.43^{b}	2.55 ±1.0^{a}	196.3 ±93.53^{a}	24.43 ±2.51^{a}
PRP 85861.11	10.85 ±0.66^{a}	118.95 ±17.60^{a}	6.2 ±0.75^{a}	174.7 ±16.93^{a}	0.95 ±0.9^{b}	73.90 ±52.81^{b}	24.5 ±4.59^{a}
Desiree	4.75 ±1.23^{b}	51.25 ±11.70^{b}	3.95 ±0.19^{bc}	133.35± 16.55^{ab}	1.35 ±0.7^{b}	94 ±48.71^{b}	18.57 ±4.34^{b}
F test	**	*	**	*	**	**	*
P value	0.0024	0.0455	0.00447	0.0181	0.00713	0.00847	0.02239
CV%	31.61	38.27	20.03	20.01	37.67	41.39	13.20
LSD	2.96	43.20	1.336	43.30	0.81	66.92	4.39

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Note: USN=Undersize (<25gm) number, SSN=Seed size (25-50gm) number, OSN= Oversize (>50gm) number, USW= Undersize (<25gm) weight, SSW=Seed size (25-50gm) weight, OSW=Over size (>50gm) weight, LSD=Least Significant Difference, CV%=Coefficient of Variation Percentage

The variation in tuber yield of clones was found statistically significant. PRP 85861.11 (24.5mt/ha), CIP 388676.1(24.43mt/ha) and PRP 226267.11(24.38mt/ha) were found statistically similar and superior for tuber yield. Desiree (18.57 mt/ha) produced the least yield among the tested clones.

Among the six tested clones, three were oval shaped, two were oblong shaped and one was round in shape. The tubers of 2 clones were with shallow eye, 2 with medium and 2 with deep eyes. Regarding the tuber color, 2 clones were white colored, 3 with red color and one with yellow color. Similarly, variation was noticed in tuber flesh color as mentioned in Table 5.

Table 5. Variation in tuber characteristic among potato clones in Bhaktapur, 2018

Treatment	Shape	Eye depth	Tuber color	Tuber Flesh color
PRP 35861.18	Oval	Medium	White	White
CIP 384866.5	Round	Deep	Yellow	Pale yellow
PRP 226267.11	Oval	Medium	Red	Cream
CIP 388676.1	Oval	Shallow	White	White

PRP 85861.11	Oblong	Deep	Red	Cream
Desiree	Oblong	Shallow	Red	Yellow

Based on the external appearance of tuber and the total production, PRP 226267.11 held the first position by farmer's ranking. Organoleptic taste ranking of boiled potato reported PRP 85861.11 as the most delicious clone among all (Table 6)

Table 6. Farmers' ranking and organoleptic taste ranking

Treatment	Farmer's ranking	Organoleptic taste ranking of boiled potato
PRP 35861.18	3	5
CIP 384866.5	5	2
PRP 226267.11	1	3
CIP 388676.1	2	6
PRP 85861.11	4	1
Desiree	6	4

DISCUSSION

The potato clones tested at CFFT, RARS Nepalgunj (NPRP, 2016/17) reported that there is significant variation in germination at 30DAP. The lower germination of promising clones as compared to Desiree might be due to presence of some growth inhibitors in seed tuber and its susceptibility to prolonged frost at early period of planting. Burton and Meigh (1971) also reported that benzothiazole, 1,4-dimethylnaphthalene and 1,6-dimethylnaphthalene are comparatively potent inhibitors of sprout growth in the potato tuber. PRP 35861.18 and CIP 388676.1 had shown the highest and lowest plant vigour respectively in our study which corresponds to the finding of Upadhyay et al. (2017). Ahamad et al. (2012) reported non significant variation in plant uniformity, ground cover and late blight. It might be due to different genotypes, weather and environmental condition.

Upadhyay et al. (2017) reported PRP 35861.18 and CIP 388676.1 as the tallest and shortest clones respectively among the tested clones which agrees with our findings. Significant variation in plant height among the genotypes was observed in Gautam et al. (2004) and Ghimire et al. (2004). Abbas (2011) reviewed and reported that varieties vary in

flesh and skin colour, eye depth and tuber shape.

Upadhyay et al. (2017) reported significant variation in number of seed size tuber and over size tuber only but the finding of this study showed significant variation in number of all tubers types. Cho and Iritani (1983) reported that tuber number is function of stem population but is influenced by cultivars and several other factors, which control vegetative growth. Dhakal et al. (2011) and Chapagain et al. (2014) reported that the varieties significantly influenced the yield of tuber per plant. According to Upadhyay et al. (2017) PRP 85861.11 gave the highest yield and Desiree produced the lowest among 6 tested clones which is quite similar to our finding. It might also be due to similar environmental condition of Bhaktapur and Kavre.

CONCLUSION

Hence it can be concluded that all 5 promising potato clones performed better than Desiree with respect to growth and yield parameters. PRP 85861.11, CIP 388676.1 and PRP 226267.11 were the superior clones regarding the tuber yield. All the promising clones were found resistant to late blight while Desiree was found highly susceptible. PRP 35861.18 showed the better growth performance. The farmers' preference was high for PRP 226267.11 and organoleptic taste ranking boiled potato of tested clones proved PRP 85861.11 as superior one in term of taste and texture. Further research on these promising clones should be carried out so that NPRP can release and recommend the new high yielding variety for farmers.

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REFERENCES

Abbas, G. (2011). *Evaluation and selection of potato genotypes for better yield, storage and processing attributes* (Doctoral Dissertation). Retrieved from http://prr.hec.gov.pk/jspui/bitstream/123456789/870/2/1084S.pdf

Ahamad, S., Chaudhary, D.K., KC, Y.P., & Tiwari, D.N. (2012). Participatory selection of potato (Solanum tuberosum L.) genotypes for mid-western terai of Nepal.*Proceedings of the 10th National Outreach Workshop*, 27-28 February 2012, RARS, Lumle, Kaski.

Assefa, T., Abebe, G., Fininsa, C., Tesso, B., & Al-Tawaha, A. R. (2005). Participatory bean breeding with women and samll holder farmers in eastern Ethiopia. *World Journal of Agricultural Sciences, 1,* :28-35. Retrieved from http://www.fao.org/family-farming/detail/en/c/295676/

Burton, W.G., & Meigh, D.F. (1971). Production of growth suppressing volatile substances by stored potato tubers. *Potato Research* (14),96-101.

Chapagain, T.R., Tiwari, D.N., Adhikari, R.C., Khatri, B.B., & Luitel, B.P. (2014). Performance of potato clones in Mid Hill of Western Nepal. *Proceedings of the National Potato Research Workshop.*

Cho, J. L., & Iritani, W. M. (1983). Comparison of growth and yield of Russet Burbank for a two year period. *American Potato Journal, 60*(8), 567-576.

Dhakal, R., Shah, S. K., Shakya, S. M., & Basnet, K. B. (2011). Tuber yield and quality of potato chips as affected by mulch, variety, and potash levels under western Terai, Nepal**.** *Agronomy Journal of Nepal, 2*. 121-132.

Dhital, B. K., & Khatri, B.B. (2004). *Potato production in Nepal (Nepali Version).* Shradha Press, Lagankhel, Lalitpur, Nepal.

DOI: http://dx.doi.org/10.3126/ajn.v2i0.7527

Gautam, I. P., Paudel, K. B., Upadhyay, K. P., Chaudhary, J. N., & Khatri, B. B. (2004). Evalution of potato genotypes in the western hills of Nepal. *Fourth national workshop on horticulture, March 2-4, 2004.* pp. 146-153. Retrieved from http://nkcs.org.np/narc/dl/pages/view.php?ref=482&k=

Ghimire, J., Chaudhary, U. L., Gharti, D. B., Sah, R. L. (2004). Evaluation of potato genotypes in central Terai. Evalution of potato genotypes in the western hills of Nepal. *Fourth national workshop on horticulture, March 2-4, 2004.* pp. 154-157. Retrieved from http://nkcs.org.np/narc/dl/pages/view.php?ref=483&k=

Khatri, B. B., Shrestha, S. L., Ojha, D. N., & Rai, G. P. (1999). *Field book of potato germplasms evaluation.* Potato Research Program. NARC, Khumaltar, Nepal. 33 p.

MoAD. (2017). Ministry of Agriculture Development. Agri-Business Promotion and Statistics Division, Singha Durbar, Kathmandu, Nepal. 179 p.

NPRP. (2016/17). Annual Report. National Potato Research Program, Khumaltar, Lalitpur, Nepal. NPSN, 00581-394/2017/18

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://cran.r-project.org/bin/windows/base/old/3.5.1/

Romney, D. L., Thorne, P., Lukuyu, B., & Thornton, P. K. (2003). Maize as food and feed in intensive smallholder systems: management options for improved integration in mixed farming systems of east and southern Africa, Field Crops Research, 84(1-2), 159-168. https://doi.org/10.1016/S0378-4290(03)00147-3

Upadhyay, K.P., Bhattarai, P., Pandey, S., Neupane, J.D., & Khatri, B.B. (2017). Performance of promising potato clones at different research sites in Super Zone of potato. *Proceedings of the 12th National Outreach Research Workshop.Rampur, Chitwan June 18-19 2017 pp 118-121.*

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